Supplementary information 1 Selected risk assessment publications to be considered for deriving attributes for development of minimum standards for risk assessment methods, including the name of the method, study type (original or further development of an existing method), geographic and taxonomic scope to which the method has been applied, total number of questions, types of question, output and associated reference. The 33 selected risk assessment publications represent 29 methods (noting that some of the protocols were replicated within multiple publications).

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
1	A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts	Original development	Global	All groups but so far tested on birds and amphibians	10	Five semi-quantitative scenarios describing impacts under each of ten mechanism to assign species to different levels of impact	Massive, major, moderate, minor, minimal; assignment corresponding to the highest level of deleterious impact associated with any of the mechanisms	(Blackburn et al. 2014; Evans et al. 2016; Kumschick et al. 2017)
2	Australian freshwater fish model	Further development	Australia	Freshwater fish	5	Different types of predictor variables (continuous, categorical) related to species traits and environmental characteristics	Low, moderate, serious, extreme; determined from the various combinations of the three risk scores	(Bomford 2006; Bomford and Glover 2004)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
3	Australian reptile and amphibian model	Further development	Australia, UK, USA	Reptiles and amphibians	3	Different types of predictor variables (continuous, categorical) related to species traits and environmental characteristics	Low, moderate, serious, extreme; determined from the various combinations of the three risk scores	(Bomford et al. 2005)
4	Australian bird and mammal risk assessment	Further development	Australia, New Zealand	Mammals and birds	20	Different types of predictor variables (continuous, categorical) related to species traits and environmental characteristics	Low, moderate, serious, extreme; determined from the various combinations of the three risk scores	(Bomford 2008)
5	Invasive Species Environmental Impact Assessment Protocol (ISEIA)	Original development	Belgium	Selected species of several groups	4	Answers are scored on a 3-point scale	High, moderate and low environmental risk. (Black list, watch list, no list)	(Branquart 2009)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
6	A modular assessment tool for managing introduced fishes	Original development	England and Wales	Freshwater fish	49+ (FISK-based)	Four modules for prioritization, assessment, management action and costs of action	Suggestion for management action for each population	(Britton et al. 2011)
7	EPPO prioritization process for invasive alien plants	Original development	EPPO region	Plants	11	Five (Yes/No) and three (Low/Medium/High)	Phase 1: List of minor concern; Observation list; List of invasive alien plants; Phase 2: Small, Medium, Large priority for PRA;	(Brunel et al. 2010)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
8	Protocol to assess the environmental impact of pests in the EPPO decision-support scheme for pest risk analysis	Original development	EPPO-region	2 versions: plants; plant pests (pathogens and invertebrates)	8+6 (plant pests), 9+6 (plants)	Two main questions with sets of sub-questions: 9 sub-questions to assess the present impact in other invaded areas; if the answers cannot be applied to the assessment area, 6 additional questions on the potential impact in the assessment area. Uncertainty is scored for each question.	Sub-question and uncertainty scores are summarized into final scores by means of a 'rule-based matrix model. This is a module of the EPPO DSS scheme (EPPO, 2011), but can also be applied to assess present or potential impact of alien plants and plant pests.	(Kenis et al. 2012)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
9	EPPO computer-assisted pest risk assessment decision support scheme (EPPO DSS)	Further development	EPPO-region	Plant pests including weeds	48	All answers are scored on a 5-point scale (3-point for impact).	No ranking	(EPPO 2011)
10	Trinational Risk Assessment for Aquatic Alien Invasive Species (CEC)	Original development	North America (Canada, USA, Mexiko)	Aquatic species	7	Probability or impact estimates of seven elements that may be determined quantitatively or by subjective methods (Low/Medium/High)	Organism Risk Potential and Pathway Risk Potential	(CEC 2009)
11	Fish Invasiveness Screening Kit (FISK)	Further development	UK	Fish	49	Central components (e.g. rank formation) of FISK are based on A-WRA	Accept, evaluate (=need further evaluation), reject taxon	(Copp et al. 2005)
12	FISK (with uncertainty and predictive power improvements)	Application	UK	Fish	49	Central components (e.g. rank formation) of FISK are based on A-WRA	Accept, evaluation (=need further evaluation), reject taxon	(Copp et al. 2009)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
13	European Non-native Species in Aquaculture Risk Assessment Scheme (ENSARS)	Original development	EU (but most of the risk assessments are applied only to UK or even single river basins)	Species listed Annex IV of EU Regulation on the use of Aliens in Aquaculture	49+ (FISK-based)	ENSARS consists of seven modules (Entry, Invasiveness, Organism, Facility, Pathway, Socio-economic Impact, Risk Summary & Risk Management) and a 5-point scale for the assessments	Assessments can be summarised by score summation and conditional probability leading to a high, medium or low risk assignment	(Copp et al. 2008)
14	Harmonia^{+} and Pandora^{+}: risk screening tools for potentially invasive organisms	Original development	Belgium	No application yet	30	The answers to the semi-quantitative questions can be used to calculate indices that reflect the risks posed by that organism	The Invasion score and the Impact score can be aggregated by taking the product yielding an ultimate score for the Invasion risk posed by the organism assessed	(D'hondt et al. 2015)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
15	EFSA PLH Scheme for PRA	Original development	Europe	Plant pests	6 main questions with several sub-questions	Magnitude of the impact is categorized in 5 classes.	Level of overall risk related to biodiversity is categorized as Minor, Moderate or Major, while risk related to ecosystem services is categorized as Minimal, Minor, Moderate, Major or Massive.	(EFSA 2011)
16	GABLIS	Original development	Germany, Austria	Plants, vertebrates	16	Five impact criteria are scored on a 4-point scale (Yes/Assumed/No/Unknown)	Black List (with 3 sub-lists), Grey List (with 2 sub-lists), White List	(Essl et al. 2011)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
17	Full Risk Assessment Scheme for Non-native Species in Great Britain (GB NNRA)	Further development	Great Britain	All groups	80	Qu relate to screening (Y/N), entry, establishment, spread, and impact (semi-quantitative 5 point scale with confidence recorded on a 4 point scale)	Overall risk score is calculated based on all of the scores given in the assessment and presented in Risk summary sheets	(Baker et al. 2008) http://napra.eppo.org/
18	Alien Species in Norway - with the Norwegian Black List 2012	Further development	Norway	All groups	9	Nine semi-quantitative criteria on two axes, three determine species invasion potential and six the ecological impact	Five impact categories: severe, high, potentially high, low, no known impact. The two categories with the greatest impact (severe, high) form the 2012 Black List	(Gederaas et al. 2013; Sandvik et al. 2013)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
19	Risk analysis and prioritisation (Ireland and Northern Ireland)	Development	Ireland and Northern Ireland	All groups	10	Scoring system (maximum scores depend on question)	Sum of scores results in high, medium and low risk category	(Kelly et al. 2013)
20	Environmental risk assessment for plant pests: A procedure to evaluate their impacts on ecosystem services	Further development	Not applicable	Plant pests (including plants)	-	scenarios that explicitly combine qualitative and quantitative information and estimates	Five ratings for the assessment of impacts: Massive, Major, Moderate, Minor, Minimal; overall impact and uncertainty are calculated according to EFSA (2011)	(Gilioli et al. 2014)
21	Quantitative Risk Assessment for alien fishes	Development	North America (Great Lakes)	Fish	25	A quantitative model using species characteristics (Life-history, Habitat, Invasion history and Human use)	Probability model	(Kolar and Lodge 2002)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
22	A conceptual framework for prioritization of invasive alien species for management according to their impact	Development	Not applicable	All groups	12	Scoring system consisting of environmental and socio-economic criteria with 6 categories each	Final Impact Scores calculated by combining Change Assessment Score (considers ecological and socio-economic impact) and Weighted Impact Categories (considers stakeholder values)	(Kumschick et al. 2012)
23	Generic Impact-Scoring System (GISS)	Development	Europe	All groups	12	Scoring system consisting of environmental and socio-economic criteria with 6 categories each	Continuous impact ranking	(Kumschick et al. 2011; Kumschick and Nentwig 2010; Nentwig et al. 2016; Nentwig et al. 2010)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
24	Biopollution Index	Development / Original ?	Baltic Sea	All groups	5	Impact questions scored on a 5-point scale, but abundance and distribution ranges on a 3- and 4-point scale, respectively	Biopollution Level on a scale 0 (weak) to 4 (massive).	(Olenin et al. 2007; Zaiko et al. 2011)
25	Chinese WRA	Development	China	Plants	19	Questions structured hierarchically and scored into a continuous scale (from 0 to 100) based on the 'Analytic hierarchy process' (AHP)	Continuous impact ranking	(Ou et al. 2008)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
26	US Weed Ranking Model	Development	USA	Plants	27	Multiple-choice questions using different scales (ranging from 0-10 or 0-1 depending on the category)	Continuous impact ranking	(Parker et al. 2007)
27	Australian WRA	Development	Australia	Plants	49	Qu to be answered with Yes/No; magnitudes not considered	Categories: accept, evaluation (i.e. needs further evaluation), reject	(Pheloung 2001)
28	Freshwater Invertebrates Scoring Kit (FI-ISK)	Application	Italy	Crayfish	49	Yes/No/Don't know questions, with level of certainty (spread over four rankings)	High, medium, low risk	(Tricarico et al. 2010)
29	Expert System for screening potentially invasive alien plants in South African fynbos	Development	South Africa	Woody plants	24	Different types of predictor variables (continuous, categorical) related to species and environmental traits	Low or high risk	(Tucker and Richardson 1995)

	Method	Study type	Geographic scope	Taxonomic scope	Total number of questions	Type of questions	Output	Reference
30	Invasive Ant Risk Assessment	Development	New Zealand	Ants	32	Answers scored on a 3-point scale	High, medium, low risk	(Ward et al. 2008)
31	Classification key for Neophytes	Development	Central Europe	Vascular plants	12	Multiple-choice questions with different scales, always ranging between 0 and 4	High, intermediate, low risk	(Weber et al. 2005)
32	Climate-Match Score for Risk-Assessment Screening	Development	Florida (USA)	Amphibians, Reptiles	-	Distribution data	Bioclimatic modelling	(van Wilgen et al. 2009)
33	Assessment of risk of establishment for alien amphibians and reptiles	Development	California and Florida (USA)	Amphibians, Reptiles	9	Nine variables used to assess establishment success	Probability model	(van Wilgen and Richardson 2012)

Supplementary Information 2. Preliminary list of attributes derived from the review of risk assessments (see Supplementary Information 1).

Risk assessment attribute
Includes species description
Documents information sources
Can be used for a broad range of taxa
Includes the likelihood of entry, establishment, spread and magnitude of impact
Includes description of (1) the actual and potential distribution; (2) the likelihood of spread; (3) the magnitude of impact
Has the capacity to include multiple pathways of entry and spread, both intentional and unintentional
Has the capacity to include multiple pathways of secondary spread, both intentional and unintentional
Broadly assess environmental impact with respect to biodiversity and ecosystem patterns and processes
Broadly assesses environmental impact with respect to ecosystem services
Includes status (endangered or protected) of species or habitat under threat
Has the capacity to consider future impacts due to environmental change
Broadly assesses socio-economic impact
Includes assessment of monetary cost of damage
Considers socio-economic benefits
Provides a summary of the different components of the assessment in a consistent and interpretable form
Includes measure of uncertainty
Can deal with lack of data
Unbiased and objectively assesses all species regardless of current status
Compliant with WTO standards
Includes quality assurance

Supplementary Information 3: A suggested checklist of negative socio-economic impacts of IAS to be considered in risk assessments.

Socio-economic impact	Description
Negative impacts on economic sectors	Negative impacts on agriculture sector
	Negative impacts on forestry sector
	Negative impacts on animal production (including fisheries and aquaculture)
	Negative impacts on tourism
Negative impact on human infrastructure	Damage to buildings (including dams, traffic and energy infrastructure)
Negative impact on human health	Injuries (including bites, stings, scratches, rashes), transmission of diseases and parasites to humans, bioaccumulation of noxious substances, health hazard due to contamination with pathogens or parasites, as well as secondary plant compounds, toxins or allergen substances such as pollen.
Negative impact on well-being and sustainable development	Noise disturbance (e.g. by parakeets), pollution of recreational areas (water bodies, rural parks, golf courses or city parks), fouling, eutrophication, damage by trampling and overgrazing, restrictions in accessibility (e.g. by thorns, other injuring structures, successional processes, or recent pesticide application) to habitats or landscapes of recreational value. Restrictions or loss of recreational activities, aesthetic attraction or touristic value. Restrictions concerning aesthetic values and natural or cultural heritage.
	Hindering local and regional sustainable development with respect to water security, food security, natural hazard mitigation, climate change mitigation and adaptation, employment.
	Hindering diversification of sustainable of regional development

Socio-economic impact	Description
	Hindering opportunities for education, research and innovation

Supplementary Information 4: Suggested checklist of climate change aspects that may affect by IAS and should be considered within risk assessments.

Invasion stage	Aspects to consider	Description
General	Climate Water chemistry Base-flow conditions Air composition	Climate change can affect biological invasions through multiple and interacting changes in temperature and precipitation, nitrogen deposition, water-flow and sea-level, water salinity and acidification or CO_2 levels.
Introduction	Human pathways Env. Pathways	Potential changes in the origin, number and survival of propagules due to likely changes in trading routes and the frequency and intensity of extreme weather events.
Establishment	Physiological constraints Fitness	Potential increase in growth and fitness (e.g. reproduction, inter-specific competition) of invasive species if environmental conditions become closer to their optimum.
Spread	Range shift Reproduction Dispersal patterns	Potential density-dependent dispersal of invasive species if environmental conditions become closer to their optimum. Potential secondary spread facilitated by more frequent or intense extreme weather events.
Impacts	Environmental Socio-economic Ecos. Services	Potential changes in the magnitude of impacts derived from expected changes in species coverage, fitness and per-capita effects described above.

Baker R., Black R., Copp G.H. *et al.* (2008) The UK risk assessment scheme for all non-native species. pp. 46-57 in W. Rabitsch, F. Essl, F. Klingenstein editors. *Biological Invasions – from Ecology to Conservation.* Neobiota.

Blackburn T.M., Essl F., Evans T. *et al.* (2014) A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts. *PLoS Biol 12(5): e1001850 doi:101371/ journalpbio1001850*.

Bomford M. (2006) Risk assessment for the establishment of exotic vertebrates in Australia: recalibration and refinement of models. Department of the Environment and Heritage, Commonwealth of Australia.

Bomford M. (2008) Risk assessment models for establishment of exotic vertebrates in Australia and New Zealand. Invasive Animals Cooperative Research Centre, Canberra.

Bomford M., Glover J. (2004) *Risk assessment model for the import and keeping of exotic freshwater and estuarine finfish*. Bureau of Rural Sciences, Canberra.

Bomford M., Kraus F., Braysher M., Walter L., Brown L. (2005) Risk assessment model for the import and keeping of exotic reptiles and amphibians. Department of Environment and Heritage, Bureau of Rural Sciences, Canberra.
Branquart E. (2009) Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium: version 2.6. Belgian Forum on Invasive Species, Bruxelles.
Britton J.R., Copp G.H., Brazier M., Davies G.D. (2011) A modular assessment tool for managing introduced fishes according to risks of species and their populations, and impacts of management actions. *Biological Invasions* **13**, 2847-2860.
Brunel S., Branquart E., Fried G. *et al.* (2010) The EPPO prioritization process for invasive alien plants. *Bulletin OEPP/EPPO Bulletin* **40**, 407–422.
CEC. (2009) Trinational risk assessment guidelines for aquatic alien invasive species. Commission for Environmental Cooperation, Montréal
Copp G.H., Britton J.R., Jeney G. *et al.* (2008) Risk assessment protocols and decision making tools for use of alien species in aquaculture and stock enhancement. (http://www.cefas.defra.gov.uk/media/437410/impasse_44142_d3-2.pdf). p. 84pp. Report to the European Commission, Project no.: 044142 (IMPASSE – Environmental impacts of alien species in aquaculture) for Coordination Action Priority FP6 2005-SSP-5A, Sustainable Management of Europe's Natural Resources, Brussels.
Copp G.H., Garthwaite R., Gozlan R.E. (2005) Risk identification and assessment of non-native freshwater fishes: concepts and perspectives on protocols for the UK. p. 32pp. *Cefas Science Technical Report No 129.* Cefas, Lowestoft.
Copp G.H., Vilizzi L., Mumford J., Fenwick G.V., Godard M.J., Gozlan R.E. (2009) Calibration of FISK, an invasive-ness screening tool for non-native freshwater fishes. *Risk Analysis* **29**, 457-467.
D'hondt B., Vanderhoeven S., Roelandt S. *et al.* (2015) Harmonia+ and Pandora+: risk screening tools for potentially invasive plants, animals and their pathogens. *Biological Invasions* **17**, 1869-1883.
EFSA. (2011) Guidance on the environmentalrisk assessment of plant pests. p. 121 in EFSA editor.
EPPO. (2011) Guidelines on Pest Risk Analysis: Decision support scheme for quarantine pests. European and Mediterranean Plant Protection Organization.
Essl F., Nehring S., Klingenstein F., Milasowszky N., Nowack C., Rabitsch W. (2011) Review of risk assessment systems of IAS in Europe and introducing the German–Austrian Black List Information System (GABLIS). *Journal for Nature Conservation* **19**, 339-350.
Evans T., Kumschick S., Blackburn T.M. (2016) Application of the Environmental Impact Classification for Alien Taxa (EICAT) to a global assessment of alien bird impacts. *Diversity and Distributions* **22**, 919-931.
Gederaas L., Moen T.L., Skjelseth S., Hansen L.-K. (2013) Alien species in Norway: with the Norwegian Black List 2012. Artsdatabanken, Trondheim.
Gilioli G., Schrader G., Baker R.H.A. *et al.* (2014) Environmental risk assessment for plant pests: A procedure to evaluate their impacts on ecosystem services. *Science of The Total Environment* **468–469**, 475-486.
Kelly J., O'Flynn C., Maguire C. (2013) Risk analysis and prioritisation for invasive and non-native species in Ireland and Northern Ireland. Northern Ireland Environment Agency and National Parks and Wildlife Service.
Kenis M., Bacher S., Baker R.H.A. *et al.* (2012) New protocols to assess the environmental impact of pests in the EPPO decision support scheme for pest risk analysis. pp. 21-27. *Bulletin OEPP/EPPO.*
Kolar C.S., Lodge D.M. (2002) Ecological predictions and risk assessment for alien fishes in North America. *Science* **298**, 1233-1236.
Kumschick S., Alba C., Hufbauer R.A., Nentwig W. (2011) Weak or strong invaders? A comparison of impact between the native and invaded ranges of mammals and birds alien to Europe. *Diversity and Distributions* **17**, 663–672.
Kumschick S., Bacher S., Dawson W. *et al.* (2012) A conceptual framework for prioritization of invasive alien species for management according to their impact. *NeoBiota* **15**, 69-100.

Kumschick S., Measey G.J., Vimercati G. *et al.* (2017) How repeatable is the Environmental Impact Classification of Alien Taxa (EICAT)? Comparing independent global impact assessments of amphibians. *Ecology and evolution* **7**, 2661-2670.
Kumschick S., Nentwig W. (2010) Some alien birds have as severe an impact as the most effectual alien mammals in Europe. *Biological Conservation* **143**, 2757–2762
Nentwig W., Bacher S., Pyšek P., Vilà M., Kumschick S. (2016) The generic impact scoring system (GISS): a standardized tool to quantify the impacts of alien species. *Environmental monitoring and assessment* **188**, 315.
Nentwig W., Kühnel E., Bacher S. (2010) A generic impact-scoring system applied to alien mammals in Europe. *Conservation Biology* **24**, 302-311.
Olenin S., Minchin D., Daunys D. (2007) Assessment of biopollution in aquatic ecosystems. *Marine Pollution Bulletin* **55**, 379-394.
Ou J., Lu C., O'Toole D.K. (2008) A risk assessment system for alien plant bio-invasion in Xiamen, China. *Journal of Environmental Sciences* **20**, 989-997.
Parker C., Caton B.P., Fowler L. (2007) Ranking nonindigenous weed species by their potential to invade the United States. *Weed Science* **55**, 386-397.
Pheloung P.C. (2001) Weed risk assessment for plant introductions to Australia. in R.H. Groves, F.D. Panetta, J.G. Virtue editors. *Weed Risk Assessment.* CSIRO Publishing, Australia.
Sandvik H., Sæther B.E., Holmern T., Tufto J., Engen S., Roy H.E. (2013) Generic ecological impact assessments of alien species in Norway: a semi-quantitative set of criteria. *Biodiversity and Conservation* **22**, 37-62.
Tricarico E., Vilizzi L., Gherardi F., Copp G.H. (2010) Calibration of FI-ISK, an invasiveness screening tool for nonnative freshwater invertebrates. *Risk Analysis* **30**, 285-292.
Tucker K.C., Richardson D.M. (1995) An expert-system for screening potentially invasive alien plants in South-African fynbos. *Journal of Environmental Management* **44**, 309-338.
van Wilgen N.J., Richardson D.M. (2012) The roles of climate, phylogenetic relatedness, introduction effort, and reproductive traits in the establishment of non-native reptiles and amphibians. *Conservation Biology* **26**, 267-277.
van Wilgen N.J., Roura-Pascual N., Richardson D.M. (2009) A Quantitative Climate-Match Score for Risk-Assessment Screening of Reptile and Amphibian Introductions. *Environmental Management* **44**, 590-607.
Ward D., Stanley M., Toft R., Forgie S., Harris R. (2008) Assessing the risk of invasive ants: a simple and flexible scorecard approach. *Insectes Sociaux* **55**, 360-363.
Weber E., Köhler B., Gelpke G., Perrenoud A., Gigon A. (2005) Schlüssel zur Einteilung von Neophyten in der Schweiz in die Schwarze Liste oder die Watch-Liste. *Bot Helv* **115**, 169–173.
Zaiko A., Lehtiniemi M., Narščius A., Olenin S. (2011) Assessment of bioinvasion impacts on a regional scale: a comparative approach. *Biological Invasions* **13**, 1739-1765.